DOCUMENT RESUME

ED 030 266 EF 003 139

Computer Developments in Air Conditioning.

Pancoast, Ferendino, Grafton and Skeels, Architects, Miami, Fla.

Report No-SCR-21

Pub Date Nov 65

Note-39p.

EDRS Price MF-$0.25 HC-$2.05

Descriptors-*Air Conditioning, Air Conditioning Equipment, *Automation, Building Equipment, Computer Oriented Programs, *Computers, Computer Science, *Conference Reports, Controlled Environment, Digital Computers, Engineering, Heat, Heating, *Mechanical Equipment, Offices (Facilities)

Proceedings of a conference on the present and future uses of computer techniques in the air conditioning field. The recommendation of this report is, for the most part, negative insofar as it applies to the use of computers for design by the small office. However, there should be an awareness of their usefulness in controlling the environmental equipment specified for clients to ensure the most efficient operation. Among the papers presented are--(1) design, operation and programing and digital computers, (2) small engineering firms and the computer, (3) heat gains and losses by digital computers, (4) total energy, and (5) past, present and future of computerized control in office buildings. (RH)

ED0 30266

# SCHOOL CONSTRUCTION RESEARCH REPORT #21

# COMPUTER DEVELOPMENTS IN AIR CONDITIONING

FOR

THE DADE COUNTY BOARD OF PUBLIC INSTRUCTION



EF 003139

BY

PANCOAST, FERENDINO, GRAFTON & SKEELS
ARCHITECTS

LOCATION: BAL TABARIN ROOM
SHERMAN HOUSE HOTEL
CHICAGO, ILLINOIS

DATE: NOVEMBER 3RD AND 4TH, 1965

PROGRAM:

NOVEMBER 3, 1965

8:00 - 9:00 REGISTRATION

9:00 - 12:15 FIRST SESSION

WELCOME:

DONALD R. BANHPLET, EDITOR
"HEATING, PIPING & AIR CONDITIONING" MAGAZINE AND SPONSOR OF THIS PROGRAM.

SESSION CHAIRMAN:

A. C. KIRKWOOD
A. C. KIRKWOOD & ASSOCIATES
KANSAS CITY, MISSOURI

SPEAKERS:

MARVIN W. EHLERS
EHLERS, MAREMONT & COMPANY, INC.
CHICAGO, ILLINOIS
- DESIGN OPERATION AND PROGRAMING OF THE DIGITAL COMPUTER -

GEORGE H. GREEN, PROFESSOR OF MECHANICAL ENGINEERING
UNIVERSITY OF SASKATCHEWAN
SASKATOON, CANADA
- THE APPLICATION OF RESISTANCE - CAPACITANCE ANALOGS TO THERMAL SYSTEM DESIGN PROBLEMS -

COFFEE BREAK

STIMSON LEE
SERVICE BUREAU CORPORATION
NEW YORK, NEW YORK

- THE ROLE OF THE COMPUTER CONSULTANT IN HEATING AND AIR CONDITIONING SYSTEM DESIGN -

JAMES R. AHART
JAMES R. AHART & ASSOCIATES
DAYTON, OHIO
- SMALL ENGINEERING FIRMS AND THE COMPUTER -

12:30 - 1:30 LUNCHEON

1:30 - 5:00 SECOND SESSION

SESSION CHAIRMAN:

JOHN S. BLOSSOM
ZIEL-BLOSSOM & ASSOCIATES
CINCINNATI, OHIO

SPEAKERS:

R. L. JACKSON
STANLEY ENGINEERING COMPANY
MUSCATINE, IOWA
- HEAT GAIN AND LOSSES BY DIGITAL COMPUTER -

MAURICE G. GAMZE
GAMZE, KOROBKIN, DOLPHIN & ASSOCIATES
CHICAGO, ILLINOIS
- OUTLINE OF VARIABLE CONSIDERED FOR ENERGY STUDIES BY COMPUTER -

COFFEE BREAK

W. F. STOECKER, PROFESSOR OF MECHANICAL ENGINEERING
UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS
- SYSTEM SIMULATION - A PHASE OF COMPUTERIZED DESIGN ANALYSIS AND CONTROL OF HEATING AND AIR CONDITIONING SYSTEMS -

NASH M. LOVE
NASH M. LOVE & ASSOCIATES
WASHINGTON, D. C.
- PAST, PRESENT AND FUTURE OF COMPUTERIZED CONTROL IN OFFICE BUILDINGS -

5:30 - 6:30 COCKTAIL HOUR

6:30 - 8:30 DINNER

SPEAKER:

GABRIEL PALL
SCIENTIFIC MARKETING MANAGER
REMOTE SCIENTIFIC COMPUTING
DATA PROCESSING DIVISION
I. B. M. CORPORATION
WHITE PLAINS, NEW YORK
- SOLVING COMMUNICATIONS DIFFICULTY BETWEEN REMOTE CUSTOMER AND COMPUTER -

NOVEMBER 4, 1965

8:30 - 12:15 THIRD SESSION

SESSION CHAIRMAN:

I. A. NAMAN
I. A. NAMAN & ASSOCIATES
HOUSTON, TEXAS

SPEAKERS:

G. NEIL HARPER
SKIDMORE, OWINGS & MERRIL
CHICAGO, ILLINOIS
- AUTOMATED ANALYSIS AND DESIGN OF COOLING COILS -

J. BARRIE GRAHAM
BUFFALO FORGE COMPANY
BUFFALO, NEW YORK
- FAN SELECTION BY COMPUTER TECHNIQUES -

COFFEE BREAK

RALPH VANDIVER, JR.
BENHAM-BLAIR & AFFILIATES
OKLAHOMA CITY, OKLAHOMA
- COMPUTER DESIGN OF HIGH VELOCITY DUCT SYSTEMS -

GUY FURGIUELE
BOVAY ENGINEERS, INC.
HOUSTON, TEXAS AND

JAMES W. BRIDGES, JR.
MCDONNELL AUTOMATION CENTER
HOUSTON, TEXAS
- USING THE COMPUTER IN DUCT DESIGN -

| | |
|---|---|
| 12:30 - 1:30 | LUNCHEON |
| 1:30 - 3:30 | FORUM |

MODERATOR:

THOMAS C. ELLIOT
ENGINEERING EDITOR
"HEATING, PIPING & AIR CONDITIONING"

| | |
|---|---|
| 3:40 | DEPARTURE |

## THOSE IN ATTENDANCE FROM SOUTH FLORIDA

| | |
|---|---|
| DUFFER, R.L. | BURNS & MCDONNELL ENGINEERING COMPANY |
| HENNING, FRED K. | RADER & ASSOCIATES |
| MARTINEZ, A. | PANCOAST, FERENDINO, GRAFTON & SKEELS ARCHITECTS |
| WEBB, E. EUGENE | COSENTINO & GAM, ENGINEERS |

A TOTAL OF 156 ATTENDED THESE CONFERENCES, REPRESENTING MAINLY THE WHOLE SPECTRUM OF CONSULTING ENGINEERING FIRMS, LARGE AND SMALL, ALSO AMONG THE PARTICIPANTS WERE REPRESENTATIVES FROM:

AIR CONDITIONING EQUIPMENT AND RELATED PRODUCTS MANUFACTURERS, PUBLIC UTILITIES COMPANIES, COLLEGES AND UNIVERSITIES, NEW YORK PORT AUTHORITY, RESEARCH CORPORATIONS.

PARTIAL VIEW OF ATTENDANCE TO "COMPUTERS 65" CONFERENCE

LEFT: MR. DONALD R. BANHPLET, EDITOR - HEATING, PIPING & AIR CONDITIONING AND SPONSOR OF THIS PROGRAM.

RIGHT: MR. ART MARTINEZ, CHIEF MECHANICAL ENGINEER - PANCOAST, FERENDINO, GRAFTON & SKEELS - ARCHITECT & ENGINEERS.
ARCHITECTS TO THE BOARD OF PUBLIC INSTRUCTION, DADE COUNTY, FLORIDA

## INTRODUCTION

THE COMPUTER TODAY COVERS A BROAD FIELD OF APPLICATION, FROM THE SIMPLE TURNING OFF LIGHTS AT THE WHITE HOUSE, TO THE RESOLUTION OF THE MOST COMPLEX GUIDANCE PROBLEMS OF THIS SPACE TECHNOLOGY. OUR RAPID SCIENTIFIC AND TECHNOLOGICAL ADVANCE OF THIS PAST DECADE WE OWE MAINLY TO COMPUTERS, BECAUSE BY RELIEVING MAN FROM TEDIOUS AND TIME CONSUMING CALCULATIONS, IT GIVES HIM MORE TIME TO RESEARCH, DISCOVER AND CREATE.

IT IS IN THIS SENSE THAT WE MUST ACCEPT COMPUTERS AND NOT TO REPLACE MAN, BECAUSE HE WILL ALWAYS BE THE THINKER AND THE COMPUTER THE OPERATOR. HOWEVER, DUE TO ITS EVERY DAY INCREASING APPLICATION, THERE IS THE IMPERATIVE NEED THAT WE ACQUAINT OURSELVES WITH ITS USE, IN OUR RESPECTIVE FIELDS, OR WE WILL BE LEFT BEHIND BY THE NEW GENERATION OF PROFESSIONALS.

THIS REPORT WILL CONCERN ITSELF MAINLY WITH THE NEW DEVELOPMENTS OF COMPUTER'S USE IN THE FIELD OF AIR CONDITIONING AND VENTILATION, ALSO A BRIEF HISTORY OF THE DEVELOPMENT, ITS USE AND FINALLY A SUMMARY.

THE USE OF THE RESISTANCE-CAPACITANCE ANALOGY TO THERMAL SYSTEM DESIGN WILL NOT BE COVERED IN THIS REPORT BECAUSE, ALTHOUGH INTERESTING, IT IS NOT CONSIDERED TO BE RELATED TO COMPUTER'S USE. IN SOME SPECIFIC TOPICS ONLY A BRIEF ABSTRACT OF THE PRESENTATION WILL BE COVERED FOR REASONS LATER EXPLAINED IN THE SUMMARY.

# DESIGN, OPERATION AND PROGRAMING OF DIGITAL COMPUTERS

THIS CONFERENCE IS DIVIDED INTO THREE ASPECTS:

I) HISTORY OF COMPUTING AND INFORMATION PROCESSING TECHNOLOGY.
II) COMPONENTS OF A COMPUTER SYSTEM.
III) DESCRIPTION OF THE SET OF PROCEDURES THROUGH WHICH THE USER, THE PROGRAMMER AND COMPUTER OPERATORS MUST PROGRESS IN ORDER TO MAKE USE OF THE COMPUTER SYSTEM.

## I) HISTORY OF COMPUTING AND INFORMATION PROCESSING TECHNOLOGY.

COMING INTO THE AREA OF RECORDED HISTORY PROBABLY THE FIRST KNOWN CALCULATING DEVICE IS THAT INVENTED IN 1642 BY A NINETEEN YEAR OLD, PLAISE PASCAL. THE DEVICE WAS INVENTED BY PASCAL BECAUSE HE WAS TIRED OF ADDING LONG COLUMNS OF FIGURES IN HIS FATHER'S CUSTOMS OFFICE IN ROUEN, FRANCE.

PASCAL WAS FOLLOWED BY LEIBNITZ (1671), HAHN (1770), THOMAR (1820), HILL (1857), EACH ONE CONTRIBUTING NEW IDEAS AND IMPROVING PASCAL'S ORIGINAL CONCEPT, BY 1920 BALDWIN AND MONROE HAD DEVELOPED THE FIRST FULLY AUTOMATIC CALCULATOR.

IN 1812, CHARLES BABBAGE, A MATHEMATICS PROFESSOR AT OXFORD, BEGAN DESIGNING A "DIFFERENCE ENGINE" CAPABLE OF CARRYING OUT A SERIES OF ARITHMETIC OPERATIONS INSTEAD OF DOING JUST ONE CALCULATION AT A TIME. THIS HE COMPLETED IN 1822. BY 1833 HE EMBARKED ON THE DESIGN OF AN "ANALYTICAL ENGINE" WHICH HAD MANY OF THE ATTRIBUTES OF THE MODERN DAY COMPUTER.

UNFORTUNATELY, BECAUSE BABBAGE'S DIFFICULTY WAS COMMUNICATING HIS IDEAS TO OTHERS AND BECAUSE HE WAS SIMPLY AHEAD OF THE TECHNOLOGY AT THE TIME, NOTHING CAME OF HIS IDEAS FOR ALMOST A CENTURY.

THE PUNCH CARD IDEA, HOWEVER, DID CATCH ON AGAIN IN THE LATE 1880'S WHEN DR. HERMAN HOLLERITH OF THE U.S. CENSUS BUREAU USED THE IDEA TO ASSIST IN HANDLING THE CENSUS OF 1890. DR. HOLLERITH, WHO WAS LATER TO FORM THE I.B.M. CORPORATION, REALIZED THAT SOME MECHANICAL MEANS HAD TO BE FOUND TO HANDLE THE INCREASING BULK OF DATA FROM THE U.S. CENSUS OPERATIONS. NOT ONLY DID DR. HOLLERITH USE THE IDEA OF THE PUNCH CARD; BUT HE AND HIS ASSOCIATES ALSO INVENTED AN ENTIRE SERIES OF CARD HANDLING DEVICES FOR PUNCHING AND SENSING THE HOLES.

THE FIRST IMPORTANT STEP IN THE USE OF ELECTRONICS IN COMPUTING OCCURRED IN 1919 WHEN ECCLES AND JORDAN DISCOVERED THE ELECTRONIC TRIGGER CIRCUIT. THIS IS THE BASIS OF THE "FLIP-FLOP" MECHANISM IN ELECTRONIC COMPUTERS AND IS THE DEVICE WHICH ENABLES THEM TO COUNT.

CLOSER TO OUR CURRENT ERA WE FIND THAT THE REAL EMPHASIS TO COMPUTERS WHICH COMPUTE CAME FROM WORLD WAR II AND THE REQUIREMENTS OF THE MILITARY FOR BALLISTIC CALCULATIONS. BEGINNING IN 1937 WITH HOWARD AIKEN, WE HAVE THE MODERN FAMILY OF COMPUTING MACHINERY. HE WAS ABLE TO GET SUPPORT FROM I.B.M. IN 1939. THE RESULT OF THAT WORK WAS THE AUTOMATIC SEQUENCE CONTROLLED CALCULATOR, THE MARK I, COMPLETED IN 1944 AT HARVARD. MEANWHILE, AT THE UNIVERSITY OF PENNSYLVANIA, ECKERT AND MAUCHLY HAD BEEN WORKING ON THE ENIAC, THE FIRST ELECTRONIC COMPUTER.

IN 1946 PROBABLY ONE OF THE MOST MOMENTOUS ADVANCES IN COMPUTER TECHNOLOGY OCCURRED WITH THE IDEAS OF THE MATHEMATICIAN, JOHN VON NEUMAN. VON NEUMAN CONCEIVED THE IDEA OF BUILDING A MACHINE WITH A MEMORY INTO WHICH WAS PLACED NOT ONLY THE DATA BUT ALSO THE SEQUENCE OF INSTRUCTIONS AS WELL. THESE CONCEPTS WERE THEN USED IN THE DESIGN OF EDVAC AT THE UNIVERSITY OF PENNSYLVANIA IN 1945 THROUGH 1950. NEEDLESS TO SAY THIS IS THE VERY CONCEPT ON WHICH OUR COMPUTING SYSTEMS ARE NOW BASED.

COMING INTO THE 1950'S NOW WE FIND THE FIRST UNIVAC FROM SPERRY RAND BEING DELIVERED TO THE U.S. CENSUS BUREAU IN 1951 AND THE FIRST COMMERCIAL INSTALLATION TO GENERAL ELECTRIC APPLIANCE IN LOUISVILLE IN 1954.

WE HAVE, IT APPEARS, GONE INTO THE THIRD GENERATION OF EQUIPMENT HAVING PASSED THROUGH THE VACUUM TUBE TO TRANSISTOR ERA AND FROM THE TRANSISTORIZED COMPUTER TO THE INFORMATION PROCESSING SYSTEM CONCEPT.

AS WE HAVE DONE THIS, THE NUMBER OF COMPUTERS HAS GROWN TO SOMETHING APPROACHING 30,000 DIGITAL COMPUTERS NOW INSTALLED IN THE UNITED STATES.

## II) COMPONENTS OF A COMPUTER SYSTEM.

IF YOU HAVE BEEN READING THE CURRENT ADVERTISING LITERATURE OF THE COMPUTER MANUFACTURERS YOU WILL NOTICE THAT THEY HAVE TAKEN TO CALLING THEIR EQUIPMENT "COMPUTER SYSTEMS" OR "INFORMATION PROCESSING SYSTEMS". THE "SYSTEMS" IMPLIES THAT WE ARE DEALING NOW--EVEN MORE THAN IN THE PAST--WITH VARIABLE GROUPINGS OF INDIVIDUAL COMPONENTS.

PRIMARILY WE CAN SEGREGATE A COMPUTER SYSTEM--OR AN INFORMATION PROCESSING SYSTEM--INTO FOUR MAJOR AREAS. THEY ARE:

A) THE INPUT/OUTPUT FUNCTION
B) THE MEMORY
C) THE ARITHMETIC UNIT
D) THE CONTROL

## III) DESCRIPTION OF THE SET OF PROCEDURES THROUGH WHICH THE USER, THE PROGRAMMER AND COMPUTER OPERATORS MUST PROGRESS IN ORDER TO MAKE USE OF THE COMPUTER SYSTEM.

THE FIRST STEP IS THE CREATION OF A FLOW CHART AND/OR BLOCK DIAGRAM. THIS IS ESSENTIALLY A GRAPHIC REPRESENTATION OF THE PROBLEM TO BE SOLVED.

JUST FOR REVIEW, LET US STATE THAT THE DEFINITION HANDED TO THE PROGRAMMER SHOULD INCLUDE: A NARRATIVE DESCRIPTION OF THE ARITHMETIC STEPS TO BE PERFORMED; WARNINGS ABOUT EDIT CHECKS FOR VALIDITY WHICH THE PROBLEM SOLVER BELIEVES NECESSARY AND LISTINGS OF ALL INPUT AND OUTPUT FORMATS REQUIRED BY THE PROBLEM SOLVER. WITH THIS THE PROGRAMMER CAN THEN TRANSLATE THE PROBLEM SOLUTION INTO CODED FORM, HERE WE ARE TALKING ABOUT FORTRAN STATEMENTS. FORTRAN IS A COMPUTER LANGUAGE DESIGNED FOR TECHNICAL WORK.

AFTER THE CODING HAS BEEN COMPLETED - - AND IT SHOULD BE RECHECKED BEFORE GOING ON -- THE CODING SHEETS ARE USUALLY SENT TO THE KEYPUNCH SECTION WHERE A DECK OF CARDS IS PRODUCED.

INCONSISTENCIES IN LOGIC AND KEYPUNCH ERRORS AS WELL AS ERRONEOUS USE OF THE LANGUAGE CAUSE SOME PROBLEMS ALONG THE WAY. SOME OF THESE WILL CAUSE WHAT IS KNOWN AS "DIAGNOSTICS" TO PRINT OUT WHICH AUTOMATICALLY INFORMS THE PROGRAMMER OF THE CAUSE OF THE DIFFICULTY. OTHER TYPES OF ERRORS WILL SIMPLY CAUSE THE PROGRAM TO "BLOW-UP" OR TO COME TO A HALT.

THIS IS THE "DEBUGGING PHASE" AND IT CERTAINLY IS NOT UNUSUAL FOR LARGER PROGRAMS TO REQUIRE SEVERAL TRIPS TO THE COMPUTER BEFORE ALL OF THESE ERRORS ARE CLEANED OUT.

NOW WE ARE READY TO ACTUALLY TEST THE VALIDITY OF THE PROGRAM ITSELF. WE DO THIS BY PROCESSING A TEST CASE AGAINST THE COMPILED PROGRAM. RESULTS OF A RUN ORDINARILY COME OUT IN THE FORM OF PRINTED DOCUMENTS, EITHER ON OR OFF-LINE IS SHOWN HERE. IT IS CERTAINLY CONCEIVABLE THAT THE OUTPUT CAN BE IN THE FORM OF GRAPHIC DISPLAYS PUNCH CARDS OR ANY OTHER OF THE OUTPUT MEDIA AVAILABLE.

ONCE THE OUTPUT OF THE TEST CASE IS AVAILABLE THE RESULTS ARE ROUTED BACK TO THE PROGRAMMER AND TO THE PROBLEM ORIGINATOR FOR THEIR EVALUATION. IF ANY INCONSISTENCIES ARE FOUND -- AND THERE VERY OFTEN ARE-- WE MUST GO BACK TO THE PROGRAMMER AND TO HIS ORIGINAL CODING WORK IN AN EFFORT TO DETERMINE WHERE THE FALLACY LIES.

WE SHOULD ALSO POINT OUT THAT THERE ARE SOME FAVORABLE CONSIDERATIONS TOO. ORDINARILY, IN LARGE OPERATIONS THE OBJECT PROGRAM WILL BECOME PART OF A LIBRARY OF PROGRAMS WHICH MAY BE CALLED BY THE PROBLEM SOLVER WHENEVER HE ENCOUNTERS THIS PARTICULAR REQUIREMENT.

## THE ROLE OF THE SERVICE BUREAU

MANY INDIVIDUALS HAVE POSED THE FOLLOWING COMMENTS REGARDING THE IMPACT AND INFLUENCE OF ELECTRONIC DATA PROCESSING AND COMPUTERS ON HIS WORK:

A) WE CANNOT SEE THE ECONOMICS OF COMPUTER USE.
B) SMALLER FIRMS WILL PROBABLY NOT BE ABLE TO COMPETE WITH THOSE WHO CAN AFFORD COMPUTERS. NO INFLUENCE UNTIL THE INITIAL COST CAN BE MADE LOWER.
C) COMPUTERS WILL HAVE LITTLE EFFECT ON THE DESIGN OPERATIONS OF A SMALL FIRM.
D) COMPUTER SET-UP TIME PROHIBITIVE.

THESE PRECEDING COMMENTS ARE QUOTED FROM A SURVEY CONDUCTED BY HEATING, PIPING AND AIR CONDITIONING AND REPORTED IN THE SEPTEMBER ISSUE.

BY ANSWERING THE QUESTION "WHAT IS THE COMPUTER SERVICE BUREAU AND ITS ROLE?" WE WOULD LIKE TO ANSWER MR. JOE SKEPTIC. WE HOPE TO INFLUENCE HIM ENOUGH TO AT LEAST INVESTIGATE A TOOL THAT COULD EASE HIS WORK LOAD. BY REDUCING HIS WORK LOAD, THIS TOOL MAY IN TURN ALLOW HIM TO USE HIS CREATIVE TALENTS TO THEIR FULLEST EXTENT. I WOULD ALSO LIKE TO SHOW HOW EASY IT IS TO TRY A COMPUTER SOLUTION TO A PROBLEM AT MINIMAL COST.

TYPICAL OF COMPUTER SERVICE BUREAUS IS THE NEW YORK DATA PROCESSING CENTER, OR DPC, COMPUTING SCIENCES DIVISION, OF THE SERVICE BUREAU CORPORATION. THE HARDWARE PRESENTLY AVAILABLE AT THE NY DPC IS IN OPERATION ALMOST 24 HOURS, SIX DAYS A WEEK. TRAINED AND EXPERIENCED MACHINE OPERATORS PROVIDE THE SCHEDULING, OPERATION, AND SERVICING FOR THOSE CUSTOMERS WHO ARE MACHINE USERS.

A LARGE PORTION OF THE PERSONNEL OF THE NY DPC ARE PROGRAMMERS. ALL PROGRAMMERS HAVE THE REQUIRED BASIC EDUCATION IN MATHEMATICS. A RIGOROUS TRAINING PROGRAM PROVIDES YOUNG PROGRAMMERS WITH FACILITY IN THE VARIOUS MACHINE AND PROGRAMMING LANGUAGES NECESSARY TO COMMUNICATE WITH THE MACHINES.

BESIDES THE PROGRAMMING SKILLS, THE DPC PROVIDES A PERSONNEL WHO HAVE A WIDE SPECTRUM OF EXPERIENCE AND TRAINING. THERE ARE HOLDERS OF BACCALAUREATE AND GRADUATE DEGREES IN ENGINEERING, STATISTICS, PHYSICS, CHEMISTRY, BUSINESS ADMINISTRATION, AND IN THE ARTS.

THE DATA PROCESSING CENTER OFFERS TO THE PUBLIC THE FOLLOWING SERVICES:

A. MACHINE USAGE

LARGE AND SMALL COMPUTERS ARE MADE AVAILABLE FOR CUSTOMER USE ON AN HOURLY OR FRACTIONS OF AN HOUR BASIS. A USER MAY REQUIRE ONLY ONE-HUNDREDTH OF AN HOUR. AT THE PRESENT PRICING RATE STRUCTURE, THIS MAY VARY BETWEEN A CHARGE OF $.75 PER HUNDREDTH OF AN HOUR TO $6.50 FOR A UNIT.

B. PROGRAMMING

A PROGRAM MAY BE WRITTEN TO THE CUSTOMER'S SPECIFICATIONS. THE PROBLEM DEFINITION IS PRESENTED BY THE CUSTOMER AND THE SERVICE BUREAU CORPORATION, COULD PROVIDE PROGRAMMERS WHO WOULD ANALYZE THE BASIC REQUIREMENTS, RECOMMEND THE MATHEMATICAL APPROACH, PROGRAM THE PROBLEM SOLUTION, PROVIDE THE CUSTOMER WITH LISTINGS OF THE PROGRAM INSTRUCTIONS AND THE PROGRAM ITSELF ON KEYPUNCHED CARDS OR WRITTEN ON MAGNETIC TAPE. USE OF THE PROGRAM COULD BE ACCOMPLISHED ON THE SERVICE BUREAU'S MACHINES, IF THE CUSTOMER DESIRED.

C. APPLICATIONS

CERTAIN PRE-PLANNED PROGRAMS HAVE BEEN WRITTEN BY THE SERVICE BUREAU CORPORATION, AND THE USE OF THESE PROGRAMS ARE OFFERED TO CUSTOMERS AT FIXED PRICING STRUCTURES BASED UPON THE COMPLEXITY OF THE PROBLEM SUBMITTED.

THE AVAILABILITY OF LIBRARIES OF PROGRAMS IS ALSO PROVIDED BY THE SERVICE BUREAU CORPORATION. ONE OF THESE LIBRARIES IS THE SHARE ORGANIZATION OF I.B.M. SHARE IS COMPOSED OF CORPORATIONS AND OTHER ORGANIZATIONS THAT HAVE PURCHASED I.B.M. MACHINES. PROGRAMS ARE VOLUNTARILY CONTRIBUTED TO SHARE BY I.B.M. AND OTHER MEMBERS. THESE PROGRAMS ARE AVAILABLE TO ANY MEMBER OF SHARE. IF A CUSTOMER FINDS THAT A PROGRAM WILL BE SUITABLE TO HIS PARTICULAR PROBLEM, THE DPC CAN OBTAIN THE PROGRAM AND RUN IT FOR THE CUSTOMER.

PROGRAMS AVAILABLE THROUGH UNIVERSITIES ARE ALSO ADDED TO THE PROGRAM LIBRARIES IN THE DPC. FOR MANY OF THESE PRE-PLANNED APPLICATIONS, IT IS ONLY NECESSARY FOR THE ENGINEER TO COMPLETE INPUT DATA SHEETS IN ACCORDANCE WITH A DESCRIPTIVE USER'S MANUAL. THIS DATA IS SUBMITTED AND WITHIN A SHORT PERIOD OF TIME MACHINE GENERATED OUTPUT IS BACK ON HIS DESK.

THE ECONOMICS THAT ACCRUE TO AN ENGINEERING FIRM ARE MANY. HIGH CAPITAL INVESTMENT IN HARDWARE AND PERSONNEL IS NOT NECESSARY. THE SERVICE BUREAU CORPORATION PROVIDES TRAINED AND EXPERIENCED PERSONNEL TO HELP DEFINE YOUR PROBLEM, CREATE A PROGRAM FOR YOU AND TO RUN SOLUTIONS FOR DIFFERENT COMBINATIONS OF INPUT DATA. IF A PROGRAM IS AVAILABLE FROM UNIVERSITIES OR FROM AN ORGANIZATION LIKE SHARE, THERE MAY NOT BE ANY NECESSITY FOR A CUSTOM PROGRAMMING EFFORT.

THE COST OF COMPUTING SERVICES MAY BE MINIMAL COMPARED TO THE COST OF ENGINEERING SALARIES TODAY. BY PROVIDING EXPERIENCED ENGINEERS, WHO ARE ALSO TRAINED IN PROGRAMMING AND DATA PROCESSING, THE SERVICE BUREAU CAN PROVIDE A LEVEL OF PERSONNEL COMPETENCE THAT WILL FACILITATE AN ENGINEERING FIRM'S ENTRY INTO DATA PROCESSING.

PROBABLY THE MOST IMPORTANT FUNCTION OF THE SERVICE BUREAU IS THAT THIS TOOL OF HARDWARE AND SOFTWARE RELIEVES THE ENGINEER FROM THE MORE MUNDANE TASKS. THIS FREES HIS TIME FOR MORE CREATIVE WORK. CONSIDER HOW OFTEN THAT A PARTICULAR COMBINATION OF PARAMETERS FOR A DESIGN PROJECT CANNOT BE TESTED BECAUSE TIME IS NOT AVAILABLE. CONSIDER THIS QUESTION, "GIVEN SEVERAL COMBINATIONS OF INPUT PARAMETERS, WHICH COMBINATION WILL PRODUCE THE OPTIMAL LEVEL OF PERFORMANCE IN TERMS OF INITIAL COSTS, OPERATING EASE, AND EFFICIENCY IN OPERATIONS?".

QUESTIONS OF THIS TYPE HAVE BEEN ANSWERED IN THE PAST BY THE ENGINEER HAVING TO FLY BY THE SEAT OF HIS PANTS. BY PROVIDING A RAPID AND ACCURATE MEANS FOR THE GENERATION OF FACTS, THE ENGINEER CAN NOW USE HIS ENGINEERING JUDGEMENT AND CREATIVE ABILITY TO ITS FULLEST EXTENT.

# SMALL ENGINEERING FIRMS AND THE COMPUTER

DISCOUNTING THE COMPUTER IS ANALOGOUS TO CONDEMNING THE CALCULATOR OR SLIDE RULE FOR DISPLACING THE PENCIL IN THE HANDS OF THE ENGINEER. IT'S A SERIOUS MISTAKE TO DISCOUNT THE COMPUTER IN THIS BUSINESS. HOWEVER I MUST ALSO ADD THAT IT IS EQUALLY UNWISE TO EXPECT TOO MUCH OF THE COMPUTER. THE COMPUTER IS A TOOL -- A TOOL WITH TREMENDOUS POTENTIAL IN THE HANDS OF HUMANS WHO ARE CAPABLE OF MAKING IT WORK FOR THEM. PROPERLY USED, THE COMPUTER CAN MULTIPLY THE RESULTS OF THE ENGINEERS EFFORTS MANY FOLD. SPECIAL EMPHASIS WAS PUT ON "PROPERLY USED" BECAUSE THIS IS PARTICULARLY IMPORTANT AND IT'S NOT ALWAYS EASY, ESPECIALLY IF YOU INTERPRET "PROPERLY USED" TO MEAN PROFITABLY USED.

IT'S NOT TOO DIFICULT TO USE A COMPUTER PROFITABLY IN CIVIL ENGINEERING. THE NATURE OF CIVIL ENGINEERING ADAPTS BEAUTIFULLY TO COMPUTERS. OUR CIVIL ENGINEERING DEPARTMENT CAN GIVE THE FIELD NOTES TAKEN BY A SURVEY CREW TO A KEYPUNCH OPERATOR, FEED THE PUNCHED CARDS TO THE COMPUTER, AND WITHIN AN HOUR HAVE A HIGHLY ACCURATE TOPOGRAPHICAL MAP AUTOMATICALLY DRAFTED BY MACHINE.

STRUCTURAL ENGINEERING IS MORE DIFFICULT TO ADAPT TO A COMPUTER PROFITABLY BUT IT IS BEING DONE. EACH DAY BRINGS MORE AND BETTER PROGRAMS TO THE STRUCTURAL FIELD FOR MORE AND BETTER USAGE OF THE COMPUTER.

IN THE FIELD OF HEATING, PIPING AND AIR CONDITIONING, THE STORY IS A LITTLE DIFFERENT. THE COMPUTER ISN'T EASILY ADAPTED TO THIS FIELD. WHAT THIS MEANS IS, THAT WHILE IT MAY TAKE LONGER TO GET OUR MORE COMPLEX PROBLEMS PROGRAMMED FOR THE COMPUTER, AFTER IT'S DONE THE RESULTS WILL BE MUCH MORE SIGNIFICANT.

THIS DOESN'T MEAN THERE HAVEN'T BEEN IMPORTANT PROGRAMS DEVELOPED IN HEATING, PIPING AND AIR CONDITIONING -- THERE HAVE BEEN, BUT NOT TO THE EXTENT IN OTHER FIELDS OF ENGINEERING.

GENERALLY SPEAKING THE SMALL ENGINEERING FIRM (50 OR LESS EMPLOYEES) CANNOT USE THESE COMPUTERS AND SAVE MONEY. HE WOULD SAVE MONEY IF HE ANALYZED THE PROBLEM TO THE SAME DEGREE AS HE WOULD WITH THE COMPUTER, BUT HE DOESN'T. A PROGRAM FOR HEAT GAIN -- HEAT LOSS CALCULATIONS IS A GOOD EXAMPLE. NORMALLY, THE ENGINEER WILL KNOW WHEN THE MAXIMUM HEAT GAIN WILL OCCUR AND CALCULATE THE LOAD FOR THAT PARTICULAR TIME. GOOD ENOUGH?

MAYBE. BUT WHAT IF FOR THE SAME TOTAL COST YOU COULD KNOW THE HEAT GAIN FOR EVERY HOUR THROUGH THE DAY, WITH DIFFERENT THICKNESSES OF INSULATION, WITH DIFFERENT LIGHT LEVELS, AND DIFFERENT SHADE FACTORS. THEN WHEN THE CALCULATIONS WERE COMPLETE, HAVE THE INFORMATION PLOTTED OUT IN GRAPH FORM SO YOU COULD SEE HOW RAPIDLY THE LOADS PEAKED FOR HELPING DETERMINE HOW MUCH TO USE STORAGE EFFECT IN EQUIPMENT SELECTION. CERTAINLY WITH SUCH INFORMATION YOU CAN MAKE MORE INTELLIGENT ENGINEERING DECISIONS.

BUT HOW DO WE MAKE IT PROFITABLE IN DOLLARS AND CENTS? AFTER A COMPUTER HAS THE BASIC INFORMATION IT CAN MANIPULATE IT SO RAPIDLY THAT YOU CAN DO ALL SORTS OF THINGS WITH ONLY SLIGHT ADDITIONAL COST -- PROVIDING YOU HAVE A PROGRAM TO TELL IT WHAT TO DO. AFTER WE HAVE PUT THE INFORMATION INTO THE COMPUTER FOR OUR LOAD CALCULATIONS WHAT ELSE COULD WE DO WITH IT? CALCULATE THE NUMBER OF LIGHTING FIXTURES, SIZE GRILLES OR DIFFUSERS, SIZE RADIATION AND GIVE THE COST FOR EACH OF THESE. NOW IT BEGINS TO BECOME PROFITABLE. BUT WHAT IF WE HAD AN EVEN MORE SOPHISTICATED PROGRAM THAT WOULD SELECT THE MOST ECONOMICAL DUCT DISTRIBUTION SYSTEM WITHIN CERTAIN RESTRICTIONS ESTABLISHED BY THE ENGINEER AND COST OF THE SHEET METAL AND THE INSULATION; SELECT THE AIR HANDLING EQUIPMENT THAT FITS THE REQUIREMENTS OF THE CALCULATIONS AND OTHER REQUIREMENTS AS DETERMINED BY THE ENGINEER, AND TYPE OUT THE MANUFACTURERS, COST, DELIVERY, AND PERFORMANCE RATINGS BASED ON REPORTS GIVEN TO THE INFORMATION CENTER BY ALL INTERESTED PARTIES. WE COULD GO ON BUT YOU GET THE IDEA.

<u>POINT TO REMEMBER!</u> -- THOUGH YOUR INVESTMENT IN COMPUTERS FOR HP&AC TODAY WILL NOT BRING BIG RETURNS TODAY, THE TIME IS NOT FAR AWAY. PREPARE YOURSELF.

IF YOU'RE THINKING ABOUT RENTING YOUR OWN SMALL COMPUTER -- <u>DON'T.</u>

THOUGH COMPUTERS COME IN SMALL, LOW COST, CONVENIENT SIZES, THE LARGE ECONOMY SIZE IS A MUCH BETTER BUY. THE LARGE COMPUTER CENTER CAN GIVE YOU MUCH MORE FOR YOUR MONEY EVEN THOUGH $500 OR $600 PER HOUR MAY SOUND LIKE A FANTASTIC RATE. IF YOU DON'T HAVE A COMPUTER CENTER NEAR YOU BE PATIENT BECAUSE WITHIN A YEAR YOU SHOULD BE ABLE TO CONNECT INTO A LARGE COMPUTER CENTER VIA YOUR TELEPHONE WITH A MINIMUM OF INVESTMENT.

A LOOK AT THE REASONS FOR THIS POSITION:

<u>COST RATIO</u>

A COMPUTER COSTING 2 TO 3 TIMES AS MUCH CAN DO 5 TO 10 TIMES AS MUCH WORK. IT'S EASY TO SEE THE SERVICE BUREAU CAN GIVE YOU MORE FOR YOUR DOLLAR AND STILL MAKE A PROFIT.

USAGE

YOU CAN USE THE COMPUTER AS YOU NEED IT WITHOUT HAVING THE HIGH FIXED COST OF ONE IN YOUR OWN OFFICE. WHEN YOU HAVE YOUR OWN COMPUTER IT'S IMPORTANT TO KEEP IT BUSY SO THE TENDENCY IS TO PROGRAM MANY THINGS THAT CAN'T BE ECONOMICALLY JUSTIFIED. IF YOU CAN GET BY WITH A COMPUTER THAT RENTS FOR $1,000 PER MONTH YOU CAN GET ALL OF THE WORK YOU REALLY SHOULD HAVE ON A COMPUTER DONE FOR $600 ON A LARGE COMPUTER.

PROGRAMMING

THE EASE OF PROGRAMMING A LARGE COMPUTER VERSUS A SMALL ONE IS PROBABLY THE MOST IMPORTANT REASON FOR OUR DECISION. PROGRAMMING A SMALL COMPUTER IS SIMILAR TO HAVING TO MAKE A PREPARED SPEECH WITH A RESTRICTED VOCABULARY. IF YOU WERE LIMITED TO A CAREFULLY SELECTED 50 WORD VOCABULARY YOU COULD GET YOUR STORY ACROSS BUT IT WOULD BE AWKWARD AND YOU WOULD HAVE TO SPEND A GREAT DEAL OF TIME PREPARING THE SPEECH. TO WRITE THE SAME SPEECH WITH A 300 WORD LIMITATION WOULD BE SIGNIFICANTLY EASIER, AND SO IT IS WITH PROGRAMMING A LARGE COMPUTER. AND THEN IT IS SIMPLY NOT PRACTICAL TO WRITE THE MORE COMPLEX PROGRAMS, THAT ARE GOING TO BE MOST PROFITABLE, ON A SMALL COMPUTER.

AUXILIARY EQUIPMENT

THE PERIPHERAL OR AUXILIARY EQUIPMENT SUCH AS THE CARD READERS, PRINTERS, RANDOM ACCESS STORAGE, AND PLOTTERS ARE ALSO IMPORTANT PARTS OF A COMPUTER SYSTEM. THE DIFFERENCES IN SPEED AND ECONOMY IS THE SAME AS WITH THE COMPUTER BUT IN MANY INSTANCES YOU COULD NOT AFFORD TO HAVE THE DESIRABLE EXTRA EQUIPMENT AT ALL BECAUSE OF THE LOW USAGE.

CONVENIENCE

THERE IS NO QUESTION, IT IS MORE CONVENIENT TO HAVE A COMPUTER IN YOUR OFFICE THAN ACROSS TOWN. THE ONLY PROBLEM IS, YOU CAN'T ECONOMICALLY JUSTIFY HAVING THIS CONVENIENCE. HALF OF YOUR VOLUME COULD BE HANDLED BY MAIL WITHOUT ANY SIGNIFICANT COST OR INCONVENIENCE AND HALF OF WHAT'S LEFT BY TELEPHONE. THIS LEAVES PLUS OR MINUS $50.00 A MONTH TRAVEL TIME FOR WORK THAT NEEDS PERSONAL ATTENTION.

IN CONCLUSION: COMPUTERS CAN BE USED TO SOLVE DESIGN PROBLEMS, MAKE ECONOMIC ANALYSIS, DO OPTIMUM SIZING AND SELECTION OF EQUIPMENT, AND, FINALLY, MAKE DRAWINGS AUTOMATICALLY. THROUGH THESE USES, COMPUTERS

WILL IMPROVE ENGINEERING DESIGN AND PROFITS. THE USE, NOT NECESSARILY POSSESSION, OF A COMPUTER SYSTEM WILL BE A MUST IN THE COMING YEARS, EVEN IN THE SMALL ENGINEERING OFFICE.

IN HEATING, PIPING AND AIR CONDITIONING, SIGNIFICANT USE OF COMPUTERS DEPENDS ON DEVELOPMENT OF COMPLEX PROGRAMS REQUIRING LARGE INVESTMENTS OF TIME AND MONEY. DUPLICATING OF PROGRAMS IS A WASTE. IF THEY ARE GOING TO REMAIN PROGRESSIVE AND MAINTAIN THEIR POSITION AMONG THEIR LARGER BROTHERS, SMALLER FIRMS NEED TO DEVELOP COMPUTER "KNOW HOW" AND FIND AN ACCEPTABLE METHOD OF SHARING PROGRAM DEVELOPMENT COSTS.

# HEAT GAINS AND LOSSES BY DIGITAL COMPUTER

COMPUTERS ARE AVAILABLE TODAY WITH SUFFICIENT MEMORYAND COMPUTING SPEED TO ACCOMMODATE IN ONE PROGRAM ALMOST ALL THE DESIGN TECHNIQUES AND VARIATIONS A HEATING AND AIR CONDITIONING ENGINEER COULD USE ON A GREAT DIVERSITY OF PROJECTS. SUCH A PROGRAM MIGHT INCLUDE:

A) HEAT TRANSFER COEFFICIENTS FOR AS MANY TYPES OF ENGINEERING MATERIALS AS MAY BE FOUND IN BUILDING CONSTRUCTION.
B) THE COSTS OF THESE MATERIALS.
C) THE FIRST COSTS AND OPERATING COSTS OF AIR CONDITIONING AND HEATING SYSTEM COMPONENTS.
D) A LOGIC PROCEDURE TO SELECT THE MOST ECONOMICAL BUILDING INSULATING MATERIALS AND HEATING AND AIR CONDITIONING COMPONENTS.

THE RESULT WOULD BE THE ONE BEST SOLUTION TO A PARTICULAR DESIGN PROBLEM.

HOWEVER, A SMALL COMPUTER MEMORY PROBABLY WILL LIMIT THE PROGRAM TYPE TO ONE OF ANALYSIS OF A PROPOSED DESIGN RATHER THAN DESIGN OF A SYSTEM CONTAINING THE BEST BUILDING INSULATING MATERIAL AND MECHANCIAL COMPONENTS TO MEET A PERFORMANCE-TYPE HEATING OR COOLING SPECIFICATION.

THE PROGRAM DESCRIBED HEREIN COMPUTES HEAT LOSS, HEAT GAIN, AND VENTILATION REQUIREMENTS FOR EACH ROOM IN A BUILDING. IT ALSO TABULATES A BUILDING SUMMARY. THE COMPUTER FOR WHICH THIS PROGRAM WAS WRITTEN IS A CONTROL DATA G-15. IT HAS A 2,000 WORD MEMORY, A CONSOLE-TYPEWRITER WITH A 14 INCH WIDE CARRIAGE FOR PRINT-OUT AND A 250 CHARACTER PER SECOND PHOTOELECTRIC PAPER TAPE READER FOR INPUT. BOTH THE HEAT GAIN AND HEAT LOSS CALCULATION USE APPROXIMATELY 90% OF THE COMPUTER MEMORY.

INPUT DATA TO THE PROGRAM IS DIVIDED INTO TWO GROUPS. THE FIRST GROUP REMAINS CONSTANT THROUGHOUT ANY ONE PROBLEM. IT CONSISTS OF THE FOLLOWING ITEMS:

## GROUP I INPUT DATA

HEATING DESIGN DATA

1. INDOOR MINUS OUTDOOR TEMPERATURE DIFFERENCE.
2. DISCHARGE MINUS INDOOR AIR TEMPERATURE DIFFERENCE.
3. WATER TEMPERATURE DIFFERENCE.

4. EDGE HEAT GAIN FACTOR, BTUH PER FOOT.
5. CRACK AIR QUANTITIES FACTOR, CFH/FOOT.

COOLING DESIGN DATA

1. HUMIDITY RATION DIFFERENCE, POUNDS $H_2O$/POUND DRY AIR.
2. OUTDOOR MINUS INDOOR AIR TEMPERATURE DIFFERENCE FOR VENTILATION COOLING.
3. INDOOR MINUS DISCHARGE AIR TEMPERATURE DIFFERENCE.
4. SENSIBLE HEAT GAIN FACTOR FOR PEOPLE, BTUH PER PERSON.
5. LATENT HEAT GAIN FACTOR FOR PEOPLE, BTUH/PERSON.

TRANSMISSION SURFACE DATA

1. TRANSMISSION SURFACE HEAT TRANSFER COEFFICIENT, BTUH/SQ. FT./$^{O}$F.
2. TRANSMISSION SURFACE TEMPERATURE DIFFERENCE FOR HEATING.
3. TRANSMISSION SURFACE TEMPERATURE DIFFERENCE FOR COOLING AT ANY FOUR SELECTED TIMES OF DAY.

THE SECOND GROUP OF INPUT DATA APPLIED TO INDIVIDUAL ROOMS IN THE BUILDING. IT CONSISTS OF:

## GROUP II INPUT DATA

1. ROOM NUMBER.
2. NUMBER OF AIR CHANGES PER HOUR (MINIMUM).
3. NUMBER OF PEOPLE OCCUPYING ROOM.
4. VENTILATION AIR REQUIRED PER PERSON, CFM PER PERSON. OR VENTILATION AIR CHANGES PER HOUR (MINIMUM) FOR COOLING.
5. VENTILATION AIR CHANGES PER HOUR FOR HEATING.
6. HEAT LOSS EDGE LENGTH.
7. INFILTRATION AIR CRACK LENGTH.
8. WATTS PER SQ. FOOT SENSIBLE HEAT GAIN.
9. MISCELLANEOUS SENSIBLE HEAT GAIN EQUIVALENT.
10. MISCELLANEOUS LATENT HEAT GAIN.
11. ROOM LENGTH.
12. ROOM WIDTH.
13. ROOM HEIGHT.

    THE PROGRAM MEMORY ACCOMMODATES FOUR SETS OF LENGTH, WIDTH AND HEIGHT DIMENSIONS IN CASE A ROOM IS NOT REGULAR IN SHAPE.
14. TRANSMISSION AREA WIDTH.
15. TRANSMISSION AREA HEIGHT.
16. TRANSMISSION AREA TYPE NUMBER FROM PREVIOUSLY TABULATED TABLE IN GROUP I DATA.

    THE PROGRAM MEMORY ACCOMMODATES 15 SEPARATE SETS OF TRANSMISSION AREA DATA FOR ANY ONE ROOM.

## HEAT LOSS DATA

1. ROOM NUMBER.
2. ROOM AREA.
3. ROOM VOLUME.
4. TRANSMISSION AREA HEAT LOSS.
5. INFILTRATION AIR QUANTITY.
6. HEAT LOSS DUE TO TRANSMISSION AREA.
7. WATER QUANTITY, REQUIRED FOR HEATING.
8. AIR QUANTITY REQUIRED FOR ROOM HEATING.
9. AIR QUANTITY REQUIRED FOR MINIMUM AIR CHANGE.
10. AIR QUANTITY REQUIRED FOR VENTILATION DUE TO OCCUPANCY.
11. HEAT LOSS DUE TO VENTILATION REQUIREMENTS FOR OCCUPANCY.
12. HEAT LOSS DUE TO TRANSMISSION AREA, EDGE LENGTH AND VENTILATION AIR REQUIRED FOR OCCUPANCY.
13. HEAT LOSS DUE TO VENTILATION REQUIREMENTS (AIR CHANGES PER HOUR BASIS)
14. HEAT LOSS DUE TO TRANSMISSION AREA, EDGE LENGTH AND VENTILATION AIR (CHANGES PER HOUR BASIS).

EACH OF THE ABOVE ITEMS EXCEPT ROOM NUMBER IS SUMMARIZED FOR THE BUILDING AND THE SUMMARY TOTALS ARE PRINTED.

THE DATA PRESENTED AS A RESULT OF THE HEAT GAIN COMPUTATIONS ARE AS FOLLOWS:

## HEAT GAIN DATA

1. ROOM NUMBER.
2. ROOM AREA.
3. ROOM VOLUME.
4. TRANSMISSION SURFACE HEAT GAIN AT EACH OF THE FOUR SELECTED TIMES OF THE DAY.
5. HEAT GAIN DUE TO WATTS PER SQ. FT. PLUS MISCELLANEOUS SENSIBLE HEAT.
6. SENSIBLE HEAT GAIN DUE TO OCCUPANCY.
7. MAXIMUM SENSIBLE HEAT GAIN AT ANY ONE TIME OF DAY.
8. TOTAL LATENT, HEAT GAIN.
9. AIR QUANTITY, BASED ON MINIMUM AIR CHANGE PER HOUR.
10. AIR QUANTITY REQUIRED FOR ROOM COOLING.
11. TOTAL ROOM HEAT GAIN.
12. AIR QUANTITY FOR VENTILATION, ON EITHER A CFM PER PERSON OR AIR CHANGES PER HOUR BASIS (WHICHEVER WAS SELECTED AS INPUT ITEM NUMBER 4).

13. SENSIBLE HEAT GAIN DUE TO VENTILATION AIR REQUIREMENTS.
14. TOTAL LATENT HEAT GAIN.
15. TOTAL HEAT GAIN DUE TO VENTILATION.

EACH OF THE ABOVE ITEMS IS SUMMARIZED FOR THE BUILDING TOTALS EXCEPT ROOM NUMBER AND THE TOTAL HEAT GAIN IN A ROOM. THE TOTAL HEAT GAIN IS BASED ON THE MAXIMUM BUILDING TRANSMISSION AREA HEAT GAIN FOR ANY ONE PARTICULAR TIME OF DAY PLUS OTHER ROOM HEAT GAINS.

OTHER SUMMARY DATA FOR THE BUILDING IS PRINTED AS FOLLOWS:

1. GRAND TOTAL HEAT GAIN.
2. TONS OF AIR CONDITIONING.
3. SENSIBLE HEAT RATIO WITHOUT VENTILATION.
4. SENSIBLE HEAT RATION WITH VENTILATION.
5. BUILDING AIR QUANTITY, CFM, BASED ON THE COOLING TEMPERATURE DIFFERENCE.

IN PRACTICE, THE TERM "BUILDING TOTAL" IS OFTEN MISLEADING. BY TABULATING DATA IN VARIOUS ROOM ORDERS, THE BUILDING TOTALS CAN REPRESENT INSTEAD ZONE TOTALS OR FLOOR TOTALS.

THE PROGRAM PROVIDES THE SUMMARY TOTALS FOR THE BUILDING BASED ON THE U FACTORS CHOSEN. TO OBTAIN A SUMMARY BASED ON OTHER MATERIALS WITH DIFFERENT U FACTORS, ONLY THE DATA SHEET WHERE THE U FACTORS ARE TABULATED NEED BE CHANGED. THE REST OF THE DATA NEED NOT BE RE-EXAMINED. THE SAME IS TRUE IF ANY OF THE DESIGN TEMPERATURE DIFFERENCES OR OTHER DESIGN DATA TABULATED IN THE FIRST GROUP OF INPUT IS CHANGED. THE RECOMPUTATION BASED ON DIFFERENT DATA PROVIDES AN OPPORTUNITY FOR THE COMPUTER TO SAVE THE ENGINEER A GREAT DEAL OF TIME AND EFFORT. ALTERNATE SOLUTIONS TO A PROBLEM CAN BE OBTAINED WITH VERY LITTLE ADDITIONAL WORK BY THE ENGINEER.

THIS PROGRAM HAS BEEN USED BY ENGINEERS TO COMPUTE BUILDING HEAT GAIN, HEAT LOSS AND VENTILATION REQUIREMENTS FOR PROJECTS OF AS FEW AS FOUR ROOMS AND AS MANY AS 100. IT HAS SAVED MANY MAN-HOURS OF ENGINEERING COMPUTATION. FOR INSTANCE, THE AVERAGE OPERATING TIMES FOR TYPICAL PROBLEMS ARE:

HEAT LOSS: 0.8 MINUTES PER ROOM.
HEAT GAIN: 1.1 MINUTES PER ROOM.

EACH NEW ENGINEER WHO USES THE PROGRAM CONTRIBUTES SUGGESTIONS FOR IMPROVEMENT. THIS PROCEDURE IS TYPICAL OF ENGINEERING PROGRAMS. THE TASK OF PREPARING THEM IS NEVER REALLY COMPLETED. THIS PROGRAM FOR COMPUTING HEAT GAIN, HEAT LOSS AND VENTILATION REQUIREMENTS IS PRESENTLY CLASSIFIED AS "A WORKING PROGRAM UNDER DEVELOPMENT".

## REPORT OF TOTAL ENERGY STUDY

GENERAL

THIS PROGRAM IS FOR AN ANALYSIS OF THE TOTAL ENERGY REQUIREMENTS OF A BUILDING. IT REQUIRES AS INPUT DATA, THREE BASIC SETS OF INFORMATION:

1. DATA FROM THE ENGINEERING COMPUTER SERVICES "PEAK LOAD PROGRAM".
2. WEATHER BUREAU DATA.
3. DATA SUPPLIED BY THE MECHANICAL ENGINEERING DESIGNER.

THE PROGRAM ANALYZES THE TOTAL ENERGY REQUIREMENTS OF A BUILDING ON AN HOUR BY THE HOUR AND ROOM BY ROOM BASIS AND ACCUMULATES ENERGY REQUIREMENTS AND EQUIPMENT OPERATING PRACTICES FOR A 365 DAY PERIOD.

TWO BASIC REPORTS ARE PRODUCED:

1. A MONTHLY SUMMARY REPORT.
2. AN EQUIPMENT OPERATION REPORT.

DAILY OPERATION REPORTS OR EVEN HOURLY OPERATIONAL REPORTS FOR THE 365 DAY PERIOD ARE AVAILABLE IF DESIRED.

DURING THE RUN THE PROGRAM DETERMINES, IN CONJUNCTION WITH THE MECHANICAL SYSTEM BEING ANALYZED, IF OUTSIDE AIR CAN BE USED FOR HEATING AND COOLING AND MAKES PROVISION TO PROVIDE SAME TO SPECIFIC ROOMS. THIS IS BASED ON OUTSIDE TEMPERATURE DIFFERENCES AND MAXIMUM AVAILABLE OUTSIDE AIR. ALL ROOM CONTRIBUTIONS ARE SUMMED FOR THE BUILDING TO PROVIDE A TOTAL OUTSIDE AIR CAPABILITY.

INPUT DATA

1. STRUCTURAL DETAILS OF BUILDING FOR EACH ROOM, AS REQUIRED FOR THE E.C.S. "PEAK LOAD PROGRAM".
2. HOURLY WEATHER BUREAU DATA ON INTEGRATED DRY BULB AND WET BULB TEMPERATURES FOR A 365 DAY PERIOD.
3. HOURLY ENERGY LOAD CHARACTERISTICS OF EACH ROOM TYPE FOR EACH OF THE 365 DAYS INCLUDING THE FOLLOWING LOADS:

LIGHTING (KW)
PEOPLE (QUIET, MODERATE ACTIVE, VERY ACTIVE, IN BTU).
ELECTRIC EQUIPMENT (KW)
MOTORS, UNDER 2 HP (KW)
MOTORS, OVER 2 HP (KW)
GAS EQUIPMENT
SENSIBLE BTU
LATENT BTU

4. HOURLY TEMPERATURES TO BE MAINTAINED FOR EACH ROOM TYPE FOR THE 365 DAYS.

NOTE: DAYS WITH IDENTICAL CHARACTERISTICS CAN BE INDICATED WITHOUT REPETITION OF DATA SHEETS.

5. EXCESS SOLAR LOADS HOURLY FOR THE 365 DAY PERIOD AND THE EFFECTS OF CLOUD COVER ON A PERCENTAGE BASIS.
6. INFILTRATION AND VENTILATION REQUIRED FOR EACH ROOM TYPE ON AN HOURLY BASIS FOR THE 365 DAY PERIOD.
7. HEATING AND COOLING EQUIPMENT CHARACTERISTICS, SPECIFYING KW REQUIRED FOR OPERATION. NET BTU HEATING AND COOLING CAPACITIES, AND AN HOURLY SCHEDULE OF AVAILABILITY FOR EACH ROOM TYPE FOR THE 365 DAY PERIOD.

OUTPUT REPORTS

TWO BASIC REPORTS CAN BE PRODUCED:

1. A MONTHLY REPORT OF ENERGY CONSUMPTION SHOWING THE FOLLOWING:
TOTAL KWH USAGE
DAY
NIGHT
PEAK KW DEMAND
DAY USAGE
NIGHT USAGE
TOTAL BTU BUILDING GAIN
PEAK BTU/H BUILDING GAIN
TOTAL BTU BUILDING LOSS
PEAK BTU/H BUILDING LOSS
2. A MONTHLY EQUIPMENT OPERATION REPORT SHOWING THE FOLLOWING:
NUMBER OF HOURS OF OPERATION OF EACH SPECIFIED UNIT.
NUMBER OF TIMES EACH SPECIFIED UNIT IS TURNED ON OR OFF.
EXCESSIVE BUILDING DEMANDS FOR SPECIFIED EQUIPMENT LOADS. REPORTED AT THE TIME AND DAY OF OCCURANCE AND THE AMOUNT OF SHORTAGE AND BTUS.

3. THE ABOVE REPORTS CAN BE RUN ON A DAILY OR EVEN HOURLY BASIS FOR THE ENTIRE BUILDING OR FOR SELECTIVE ROOMS. THE PRINTING OF DAILY OR HOURLY OPERATION DATA IS EXTREMELY EXPENSIVE AND COSTS OF SUCH OUTPUT MUST BE CONSIDERED SEPARATELY.

OUTPUT REPORT DETAILS - THE MONTHLY SUMMARY REPORT HAS THE FOLLOWING FORM:

| MONTH | TOTAL KWH | PEAK KW | TOTAL BTU LOSS | PEAK BTU/H LOSS | TOTAL BTU GAIN | PEAK BTU/H GAIN |
|---|---|---|---|---|---|---|
| JAN. | 1,483,000 | 500,000 | 1,600,000 | 650,000 | 800,000 | 450,000 |
| FEB. | | | | | | |
| - | | | | | | |
| - | | | | | | |
| DEC. | | | | | | |

THE EQUIPMENT OPERATION REPORT HAS THE FOLLOWING FORM:

| | FAN SYSTEM 1 | | FAN SYSTEM 2 | | HEATER 1 | | HEATER 2 | | COOLER 1 | |
|---|---|---|---|---|---|---|---|---|---|---|
| MONTH | TIMES ON/OFF | HOURS OF OPN | TIMES ON/OFF | HOURS OF OPN | NO. | HOURS OF OPN | NO. | HRS. | NO. | HRS. |
| JAN. | 34 | 200 | 69 | 300 | 75 | 500 | 75 | 500 | 0 | 0 |
| FEB. | | | | | | | | | | |
| - | | | | | | | | | | |
| - | | | | | | | | | | |
| DEC. | | | | | | | | | | |

EQUIPMENT OPERATION REPORT

EXCESSIVE BUILDING DEMAND

| | | |
|---|---|---|
| JAN. 28 | +BTU/H SUPPLIED: | 1,750,000 |
| OUTSIDE TEMP. 11° | +BTU/H DEMANDS: | 1,800,000 |
| FEB. 12 | +BTU/H SUPPLIED: | 1,750,000 |
| OUTSIDE TEMP. 9° | +BTU/H DEMAND: | 1,900,000 |
| AUG. 15 | -BTU/H SUPPLIED: | 1,500,000 |
| OUTSIDE TEMP. 92° | -BTU/H DEMAND: | 1,600,000 |

NOTE: THIS CAN BE EXPANDED TO GIVE COMPLETE 24 HOUR PICTURE ON A ROOM TYPE BY ROOM TYPE BASIS.

# SYSTEM SIMULATION

THIS PAPER FIRST REVIEWS SOME OF THE PRESENT AND NEAR-FUTURE APPLICATIONS OF DIGITAL COMPUTERS TO HEATING AND AIR CONDITIONING SYSTEMS. THESE APPLICATIONS HAVE ALL BEEN ATTEMPTED IN ONE FORM OR ANOTHER, BUT THEIR USAGE IS NOT AT ALL WIDESPREAD. THE NEXT FEW YEARS SHOULD SEE A PRONOUNCED EXPANSION OF THESE APPLICATIONS AND A REFINEMENT OF METHODS. THE SECOND PORTION OF THIS PRESENTATION FOCUSES ON "SYSTEM SIMULATION" WHEREIN THE COMPUTER REPRODUCES THE LOADS IMPOSED BY THE BUILDING AND PREDICTS HOW THE HEATING AND COOLING SYSTEM WILL BEHAVE DURING A WIDE RANGE OF OPERATING CONDITIONS. THE THIRD AND FINAL PORTION OF THIS PAPER ILLUSTRATES A METHOD FOR PREDICTING THE CAPACITY OF A COOLING UNIT WHICH WOULD BE ONE STEP IN SYSTEM SIMULATION.

I) HOW THE COMPUTER CAN ASSIST IN THE DESIGN AND OPERATION OF HEATING AND AIR CONDITIONING SYSTEMS.

SIX AREAS OF APPLICATIONS OF COMPUTERS TO THE DESIGN OF HEATING AND AIR CONDITIONING SYSTEMS WILL BE DESCRIBED BRIEFLY.

1. HEATING AND COOLING LOAD CALCULATIONS.
   THIS APPLICATION COMPUTERIZES THE PROCEDURES FOR CALCULATING THE HEATING OR COOLING LOADS OF A BUILDING IN ORDER TO SELECT THE SIZE OF THE EQUIPMENT.
2. ANNUAL ENERGY COSTS.
   AN EXTENSION OF THE HEATING AND COOLING LOAD CALCULATION IS THE CALCULATION OF ENERGY COSTS. INSTEAD OF CONFINING INTEREST TO THE HEATING AND COOLING LOADS AT ONLY THE DESIGN CONDITION, THE CALCULATION OF THE EXPECTED ENERGY COSTS MUST INCORPORATE THE STATISTICAL DISTRIBUTION OF OUTDOOR CONDITIONS THROUGHOUT THE YEAR.
   TRANSLATING THE HEATING AND COOLING LOAD INTO AN ENERGY COST MAY BE A STRAIGHTFORWARD PROCESS WITH SUCH INSTALLATIONS AS ELECTRICAL RESISTANCE HEATING SYSTEMS. THE TRANSLATION WILL BE MORE COMPLEX WHEN A SYSTEM SUCH AS AN ELECTRIC HEAT PUMP OR A GAS TOTAL-ENERGY SYSTEM IS USED, BECAUSE THE LEVELS OF OPERATING TEMPERATURES WILL AFFECT THE RELATIONSHIP BETWEEN OPERATING COST AND CAPACITY. SOME OF THE PRINCIPLES THAT ARE DISCUSSED IN THIS PAPER UNDER "SYSTEM SIMULATION" ARE APPLICABLE TO THIS CALCULATION.

3. EQUIPMENT SELECTION FOR MINIMUM COST.

THE COMPUTER LENDS ITSELF TO OPTIMIZATION PROCEDURES IN SEVERAL WAYS. FOR EXAMPLE, THE RATE OF WATER FLOW CIRCULATED THROUGH THE CONDENSER AND COOLING TOWER CAN BE OPTIMIZED. A LOW RATE OF WATER FLOW PROVIDES LOW PUMPING COSTS, BUT INCREASES THE CONDENSING TEMPERATURE AND THE POWER REQUIRED BY THE COMPRESSOR. THE COMPUTER COULD BE PROGRAMMED TO ESTIMATE THE TOTAL OPERATING COSTS FOR A NUMBER OF WATER FLOW RATES, AND THE DESIGNER COULD SELECT THE FLOW RATE THAT RESULTS IN MINIMUM COSTS.

THE FOREGOING PROCEDURE MAY BE ADEQUATE WHEN ONLY ONE VARIABLE IS BEING ADJUSTED. IF A NUMBER OF VARIABLE ARE UNDER INVESTIGATION SIMULTANEOUSLY, A MORE SYSTEMATIC AND MATHEMATICAL PROCEDURE MUST BE USED. IF THE SIZES OF THE WATER CHILLER, THE COOLING TOWER AND AIR--COOLING COILS ARE TO BE SPECIFIED FOR MINIMUM TOTAL FIRST COST, THERE IS THEORETICALLY AN INFINITE NUMBER OF POSSIBLE COMBINATIONS OF THESE COMPONENTS THAT WILL PROVIDE THE DESIRED CAPACITY. ACTUALLY THERE IS A LARGE BUT FINITE NUMBER OF COMBINATIONS SINCE THE COMPONENTS CAN BE PURCHASED ONLY IN DISCRETE INCREMENTS OF SIZE.

4. CONTROL OF SYSTEM OPERATION.

THIS COMPUTER APPLICATION CONTROLS THE SEQUENCE OR TIMES OF OPERATION OF VARIOUS MECHANICAL DEVICES IN A BUILDING ACCORDING TO PREDETERMINED INSTRUCTIONS. FANS, PUMPS, AND COMPRESSORS MAY BE STARTED AT CERTAIN TIMES OF THE DAY OR ON DAYS OF THE WEEK, OR THEIR OPERATION MAY BE DICTATED BY INTERNAL HEATING OR COOLING LOADS OR BY OUTDOOR CONDITIONS.

5. CONTROL OF SYSTEM FOR OPTIMUM EFFICIENCY.

SOME CHEMICAL AND PROCESS INDUSTRIES CONTROL THEIR OPERATIONS BY COMPUTER SO AS TO ACHIEVE OPTIMUM EFFICIENCY OR MAXIMUM PROFIT.

WE DO NOT ENVISION THIS APPLICATION OF COMPUTERS AS A LIKELY ONE FOR THE HEATING AND AIR CONDITIONING INDUSTRY. THE COMPUTER CONTROL OF A HEATING AND AIR CONDITIONING SYSTEM CAN LEAD TO EFFICIENT OPERATION, BUT SUCH DECISIONS AS TO USE OUTDOOR AIR FOR COOLING WHEN ITS TEMPERATURE FALLS BELOW, LET US SAY, 60 F CAN BE INCORPORATED INTO THE PROGRAM DISCUSSED IN THE PREVIOUS SECTION.

II) SYSTEM SIMULATION.

SYSTEM SIMULATION IN THE HEATING AND AIR CONDITIONING OF A BUILDING CONSISTS OF PREDICTING THE OPERATION CONDITIONS AT VARIOUS LOADS AND AMBIENT CONDITIONS.

SYSTEM SIMULATION MIGHT BE USED ON SEVERAL DIFFERENT OCCASIONS: (1) IN REFINED CALCULATIONS OF HEATING AND COOLING LOADS, (2) IN CALCULATION OF ENERGY REQUIREMENTS OF ELECTRIC HEAT PUMPS AND GAS TOTAL ENERGY SYSTEMS, AND (3) CHECKING IN THE DESIGN STAGE THE FULL RANGE OF OPERATING CONDITIONS TO DETECT OPERATING DEFICIENCIES.

III) PREDICTION OF SYSTEM PERFORMANCE WHEN COMPONENT PERFORMANCE IS KNOWN.

MOST OF THE FOREGOING PORTION OF THE PAPER HAS BEEN A GENERAL DISCUSSION FIRST OF SOME COMPUTER APPLICATIONS TO HEATING AND AIR CONDITIONING AND THEN TO SYSTEM SIMULATION. THE MOST SPECIFIC PORTION OF THIS PAPER PRESENTS SOME TECHNIQUES FOR SYSTEM SIMULATION AND ILLUSTRATES THE TECHNIQUES WITH A SIMPLE EXAMPLE. THE FUNCTION OF SYSTEM SIMULATION IS TO PREDICT THE VALUE OF SUCH QUANTITIES AS CAPACITY, POWER REQUIREMENTS, PRESSURES, TEMPERATURES, AND FLOW RATES OF AN INTERRELATED COLLECTION OF COMPONENTS WHEN THE INDIVIDUAL PERFORMANCE OF EACH COMPONENT IS KNOWN.

# PAST, PRESENT AND FUTURE OF COMPUTERIZED CONTROL IN OFFICE BUILDINGS

AUTOMATION HAS BEEN USED SINCE 1935 IN BUILDING OPERATION AND MAINTENANCE, STARTING WITH CENTRALIZED CONTROL OF AIR CONDITIONING SYSTEMS AND EXTENDING TO PRESENT-DAY SCHEMES INVOLVING THE PRACTICAL USE OF TELEMETERING SYSTEMS, DATA LOGGING AND ALARM-SCANNING SYSTEMS AND FINALLY TO COMPUTER-ORIENTED CONTROL SYSTEMS.

COMPUTERS CAN AND WILL BE USED TO AUTOMATE THREE GENERAL AREAS IN BUILDING, NOTABLY:

1. OPTIMIZING DESIGN AND OPERATION OF MECHANICAL AND ELECTRICAL SYSTEMS FOR VISUAL-THERMAL ENVIRONMENTS.
2. EXPEDITING THE BASIC PURPOSES FOR WHICH THE BUILDING WAS INITIALLY CONSTRUCTED, AND
3. CENTRALIZING THE BUILDING'S BASIC SAFETY AND COMMUNICATIONS SYSTEMS.

THE NEW BUILDINGS BEING DESIGNED AND BUILT TODAY ARE AS MUCH SOPHISTICATED ENERGY MACHINES AS STRUCTURES, AND, AS SUCH, CAN GREATLY BENEFIT FROM AUTOMATION ADVANCES. THE VISUAL-THERMAL ENVIRONMENTS DEMANDED IN THESE STRUCTURES RESULTS IN ANNUAL OPERATING AND MAINTENANCE COSTS OF $1.65 TO $1.90 PER SQUARE FOOT OF NET USABLE SPACE.

TO OVERCOME RISING OWNING, OPERATING AND MAINTENANCE CHARGES AND THE RESULTING PRICE SQUEEZE, BUILDING OWNERS AND CONSULTING ENGINEERS LOOK TO THE COMPUTERIZED BUILDING FOR PART OF THE SOLUTION. BECAUSE TODAY'S NEW BUILDINGS ARE AS MUCH ENERGY MACHINES AS THEY ARE STRUCTURES, WE KNOW THEY CAN BE AUTOMATED TO A MUCH GREATER EXTENT. WITH THE DEVELOPMENT OF RELATIVE INEXPENSIVE, RELIABLE CONTROL COMPUTERS WITH THEIR ABILITY TO PERFORM LONG SEQUENCES OF COMPUTATIONS AT ENORMOUS SPEED AND ABILITY TO MAKE LOGICAL DECISIONS THAT ALTER FUTURE ACTIONS, ALL WITHOUT HUMAN INTERVENTION, BUILDINGS CAN BE AUTOMATED TO A POINT WHERE THEY NOT ONLY PAY FOR THEMSELVES BUT ACTUALLY RETURN A PROFIT TO THE OWNERS.

UNFORTUNATELY, MANY BUILDING OPERATORS STILL DO NOT FULLY UNDERSTAND HOW TO USE THEIR AUTOMATED DEVICES AT PEAK EFFICIENCY. BUILDING OPERATORS, MORE OFTEN THAN NOT, ARE OVERWHELMED BY THE RAW DATA MADE AVAILABLE TO THEM AND THE OPERATING RESULTS OF AUTOMATION IN BUILDINGS HAS NOT ALWAYS BEEN GOOD. AS BUILDING OWNERS AND OPERATORS BECOME MORE FAMILIAR WITH THE MECHANICAL BRAINS AT THEIR DISPOSAL, THE PERIOD OF DISENCHANTMENT WILL PASS.

AN EXAMPLE OF COMPUTER CONTROL IS THE 33-STORY TENNESSEE GAS TRANSMISSION COMPANY BUILDING IN HOUSTON. NOW THREE YEARS OLD, THE HOUSTON BUILDING PROVIDES ONE MILLION, ONE HUNDRED THOUSAND SQUARE FEET OF OFFICE SPACE.

COMPUTER CONTROL WAS FEASIBLE FOR TENNESSEE GAS BECAUSE THE COMPANY ALREADY HAD A LARGE ELECTRONIC DATA PROCESSING GROUP ON THE PAYROLL. COMPANY OFFICIALS FELT THESE MEN HAD THE ABILITY TO HANDLE THE COMPUTATIONS NECESSARY TO OPTIMIZE THE AIR CONDITIONING SYSTEM.

TENNESSEE GAS INVESTED ABOUT 160 THOUSAND DOLLARS IN HARDWARE AND PROGRAMMING TO USE THE COMPUTER FOR THIS PURPOSE AND ESTIMATED THAT THE COMPANY WOULD SAVE $42,800 A YEAR. EXPERIENCE IS, HOWEVER, THAT THE ACTUAL SAVINGS ARE RUNNING AT A RATE OF $70,000 A YEAR. WITH WHAT THEY HAVE LEARNED, AND WITH EXPANDED USAGE, THEY EXPECT THE INVESTMENT TO BE FULLY LIQUIDATED IN ABOUT ONE MORE YEAR OF OPERATION.

NASH M. LOVE AND ASSOCIATES, SERVED AS THE CONSULTING ENGINEERS ON THE 13-STORY INTERNATIONAL MONETARY FUND BUILDING, WITH 445,000 SQUARE FEET OF OFFICE SPACE, WHICH IS NOW BEING ERECTED IN WASHINGTON, D. C. AFTER CONSIDERABLE STUDY AND INVESTIGATION, WE CONCLUDED THAT AN ON-LINE COMPUTER CLOSED-LOOP SUBSYSTEM CONTROL WAS ECONOMICALLY JUSTIFIABLE, BECAUSE IT WOULD RESULT IN ANNUAL OPERATING SAVINGS OF SIX AND A QUARTER CENTS PER SQUARE FOOT. THE OWNER, WHEN PRESENTED WITH THE RESULTS, CONCURRED IN OUR RECOMMENDATION AND THE COMPUTERIZED CONTROL WAS INCORPORATED INTO THE BUILDING DESIGN.

SOME OF OUR FINDINGS ABOUT THE USE OF AN ON-LINE COMPUTER CLOSED-LOOP SUBCONTROL SYSTEM FOLLOW:

WE FOUND THAT THERE COULD BE SUBSTANTIAL SAVINGS IN AIR CONDITIONING POWER AND FUEL COSTS. BY USING EFFICIENCY-SEEKING PROGRAMMING TO OPERATE THE THREE REFRIGERATION COMPRESSORS, WE DISCOVERED PLANT EFFICIENCY WOULD BE INCREASED BY 9.4 PERCENT.

WE ALSO DETERMINED THAT AN 11 PERCENT REDUCTION IN ELECTRICAL DEMAND CHARGES BETWEEN MAY AND OCTOBER COULD BE OBTAINED IF THE COMPRESSORS WERE PROGRAMMED TO MATCH ACTUAL BUILDING LOADS. PULSE OUTPUTS FROM THE COMPUTER ARE CONVERTED TO PRECISE PUSH-PULL MOVEMENTS TO REGULATE THE OUTPUT OF EACH COMPRESSOR.

IT WAS ALSO FOUND THAT BY ALLOWING THE COMPUTER TO ANALYZE THE INTERNAL SENSIBLE AND LATENT HEAT LOADS UNDER ALL CONDITIONS AND RESET THE AIR HANDLING UNIT, A FURTHER 5 PERCENT REDUCTION IN REFRIGERATION LOADS COULD BE OBTAINED.

ANALYSIS TOLD US THAT IF WE USED THE COMPUTER TO PROGRAM OUTSIDE VENTILATION AIR TO COMFORM WITH THE NORMAL OCCUPANCY OF THE BUILDING, WE WOULD COME UP WITH A SEVEN AND A HALF PERCENT REDUCTION IN COOLING AND VENTILATION LOADS. THIS SAME PROGRAM, WHEN USED IN CONJUNCTION WITH THE BUILDING LIGHTS, WOULD REDUCE THE HEATING COSTS BY 5 PERCENT.

THE LIGHTS IN THE BUILDING ARE AUTOMATICALLY TURNED ON AND OFF BY THE COMPUTER AT PREDETERMINED TIMES. HOWEVER, THE COMPUTER WILL DECIDE WHETHER IT IS MORE ECONOMICAL TO PROVIDE HEAT BY TURNING ON THE LIGHTS EARLY TO PROVIDE WARMUP THAN TO UTILIZE THE BOILERS.

IN ADDITION TO THE FOREGOING CUTS IN OPERATING COSTS, THERE WOULD BE CONCOMITANT SAVINGS IN MAINTENANCE, SAVINGS IN INCREASED COMFORT AND ADDITIONAL SAVINGS IN MAKING THE MECHANICAL EQUIPMENT LAST LONGER.

BECAUSE THE COMPUTER WILL ANALYZE THE OPERATIONAL EFFICIENCIES OF EACH MAJOR PIECE OF EQUIPMENT, IT WILL BE EASY TO DETERMINE WHEN THE EFFICIENCY IS DROPPING AND GIVE ADVANCE NOTICE WHEN MAINTENANCE IS REQUIRED. THE VARIABLE SCHEDULES RESULTING FROM COMPUTER ANALYSIS OF EQUIPMENT WILL MAKE FOR MORE EFFICIENT UTILIZATION OF MAINTENANCE PERSONNEL.

AND, OF COURSE, REPAIRS WILL BE LESS FREQUENT AND LESS MATERIALS WILL BE REQUIRED BECAUSE THERE WILL BE FEWER TEAR DOWNS FOR MAINTENANCE. MORE-OVER, BECAUSE THE EQUIPMENT WILL BE CONSTANTLY MONITORED BY THE COMPUTER, THERE WILL BE AUTOMATIC SHUT DOWNS OF FAULTY EQUIPMENT BEFORE EXTENSIVE DAMAGE.

THE CONSULTING ENGINEERING FIRM AND THE BUILDING OWNERS ARE CONVINCED THAT THERE WILL BE AN APPRECIABLE RETURN FROM BETTER LIFE EXPECTANCY OF THE MECHANICAL EQUIPMENT, MORE EFFICIENT OPERATION AND SHORTENED HOURS OF OPERATION AS A RESULT OF COMPUTER USAGE. WE REALLY DON'T KNOW HOW MUCH THIS SAVINGS WILL ULTIMATELY BE. AS A RESULT, IN MAKING OUR ESTIMATES, WE USED A TAKEN FIGURE OF ONE DOLLAR A YEAR AS THE ANNUAL SAVINGS RESULTING FROM THE EXTENDED LIFE OF THE MECHANICAL EQUIPMENT.

FOR THE SAME REASON, WE HAVE USED THE DOLLAR A YEAR FIGURE AS THE ANNUAL SAVINGS IN IMPROVED COMFORT. HOWEVER, WE KNOW THAT THE COMPUTER WILL OBSERVE TRENDS IN OPERATING EFFICIENCY AND TAKE REMEDIAL ACTION BEFORE MALFUNCTION OCCURS. THERE WILL BE FEWER UNSATISFACTORY CONDITIONS IN OCCUPIED AREAS AS THE COMPUTER ANTICIPATES TROUBLE AND GIVES EARLY WARNING.

THE BEST PART OF THE COMPUTERIZED BUILDING THAT WE HAVE JUST DESCRIBED -- AT LEAST AS FAR AS THE BUILDING'S OWNERS ARE CONCERNED -- IS THAT THE

SAVINGS WILL PAY FOR THE COMPUTER IN ONLY 27 MONTHS OR LESS, EVEN WITH THE USE OF ARBITRARY FIGURES OF ONE DOLLAR A YEAR IN SOME CASES. NOW THAT ACTUAL PROGRAMMING AND DEBUGGING ARE COMPLETE, WE WOULD NOT BE TOO SURPRISED TO SEE THE COMPUTER EQUIPMENT PAID FOR IN FAR LESS TIME.

COMPUTERIZED BUILDINGS MAY NOT SOUND AS EXOTIC AS MANNED LANDINGS ON THE MOON, BUT COMPLETELY AUTOMATED BUILDINGS ARE IN THE SAME TIME FRAME AS THE APOLLO LUNAR LANDING SCHEDULE AND WILL HAVE A MORE DIRECT INFLUENCE ON THE BULK OF THE WORLD'S POPULATION.

## COMMUNICATIONS DIFFICULTY BETWEEN CUSTOMER AND COMPUTER

THIS CONFERENCE ILLUSTRATED NEW ADVANCES MADE BY I.B.M. CORPORATION TOWARDS ONE OF THEIR MAIN GOALS, WHICH IS "AVAILABILITY OF COMPUTERS". PRESENTLY, TWO SYSTEMS HAVE BEEN DEVELOPED AND ARE NOW UNDERGOING THE TESTING STAGE IN ENGINEERING OFFICES AND SOME UNIVERSITIES.

THE TWO SYSTEMS DESCRIBED WERE:

A) TELEPHONE
THE CUSTOMER WILL COMMUNICATE WITH THE COMPUTER VIA A SPECIAL TELEPHONE, AND WILL IN EFFECT TALK TO THE COMPUTER, GIVING ALL OF THE DATA THAT IS NECESSARY FOR THE PURPOSE OF ACCOMPLISHING A PREDETERMINED PROGRAM.

B) TELEVISION SCREEN
A SPECIAL PENCIL WILL BE USED BY THE CUSTOMER TO WRITE ON THE SCREEN THE INPUT DATA REQUIRED BY THE COMPUTER, THIS WILL THEN BE COMMUNICATED TO THE MACHINE.

THIS TALK CONCLUDED WITH THE FOLLOWING VERY IMPRESSIVE STATEMENT:

"THE DAY IS NOT FAR AWAY, WHERE COMPUTERS IN AN ENGINEERING FIRM WILL BE REGARDED AS ANOTHER UTILITY."

# AUTOMATED ANALYSIS AND DESIGN OF COOLING COILS

A PROCEDURE IS PRESENTED FOR AUTOMATED ANALYSIS AND DESIGN OF COOLING COILS BY A MEDIUM-SIZED COMPUTER. A PROGRAM BASED ON THIS PROCEDURE IS CAPABLE OF CHECKING (ANALYSIS) A GIVEN COIL FROM A SET OF SHOP DRAWINGS OR SELECTING (DESIGN) A COIL TO MEET CERTAIN REQUIREMENTS. COILS FROM ANY MANUFACTURER CAN EASILY BE HANDLED IN A UNIFORM FASHION. THE COMPLETE COMPUTER SYSTEM IS DESIGNED WITH A HIGH LEVEL OF MAN-MACHINE COMMUNICATION IN MIND, WITH A RESULTING FINGERTIP CONTROL OF THE SYSTEM AVAILABLE TO THE ENGINEER.

# FAN SELECTION BY COMPUTER TECHNIQUES

THIS PAPER DISCUSSES THE ADVANTAGES A COMPUTER OFFERS IN DESIGNING AND ANALYZING AN AIR HANDLING SYSTEM, WHICH CONSISTS OF TWO INDEPENDENT PARTS, (1) THE DUCT SYSTEM, (2) THE FAN; AND DESCRIBES SOME NEW METHODS OF DATA PRESENTATION MADE PRACTICAL BY THE AVAILABILITY OF COMPUTER FACILITIES.

AN ANALYSIS IS MADE OF A A NEW TYPE OF FAN SELECTION GRAPHS, WHICH PERMIT THE ENGINEER A BETTER AND FASTER METHOD OF MATCHING THE PROPER FAN TO THE SYSTEM IN ORDER TO ACHIEVE EFFICIENT OPERATION. THE COMPUTER PROVIDES THE BEST MEANS OF PREPARING THE NECESSARY DATA FOR THESE GRAPHS.

THUS, THIS PAPER RECOMMENDS THAT NOT ONLY SHOULD DESIGN ENGINEERS AND FAN ENGINEERS COOPERATE IN WORKING OUT COMPUTER TECHNIQUES FOR COMPLETE SYSTEM ANALYSIS BUT THAT A BETTER METHOD BE USED FOR FAN SELECTION, EVEN WITHOUT A COMPUTER BY UTILIZING THE TYPE OF SELECTION CHART EXPLAINED IN THE PAPER.

# COMPUTER DESIGN OF HIGH VELOCITY DUCT SYSTEMS

THIS PAPER DISCUSSES THE DEVELOPMENT AND APPLICATION OF A COMPUTER PROGRAM DESIGNED TO SIZE THE DUCTS AND CALCULATE THE PRESSURE LOSSES AND REGAINS IN A HIGH VELOCITY DUCT SYSTEM.

INPUT DATA TO THIS PROGRAM CONSISTS OF: LENGTH OF RUN, TYPE OF FITTING FOR BRANCH TAKE-OFF, RATE OF AIR FLOW THRU DUCT AND A NUMBER WHICH IDENTIFIES A SPECIFIC PORTION OF THE DUCT WORK SYSTEM. TO FACILITATE INPUT DATA BREVITY AND PROGRAM SIMPLICITY ONLY FIVE TYPES OF DUCT FITTINGS ARE UTILIZED. THESE FITTINGS WERE SELECTED BECAUSE THEY ARE THE TYPES MOST COMMONLY USED AND BECAUSE THEY ARE READILY AVAILABLE FACTORY MADE PRODUCTS.

THE RESULTS OF THE COMPUTER, COMPUTATIONS, DUCT SIZES AND AVAILABLE STATIC PRESSURE ARE PRINTED IN TWO SEPARATE FORMATS:

ONE FORMAT PRINTS THE RESULT ON THE INPUT DATA TAKE-OFF SHEET, PROVIDING A PERMANENT RECORD OF BOTH DATA AND RESULTS. THE SECOND FORMAT PRINTS MORE DETAILED INFORMATION ON PRESSURE LOSSES AND VELOCITIES ENABLING THE DESIGNER TO DETERMINE THE LOCATIONS OF EXCESSIVE FITTING PRESSURE DROP THAT COULD OCCUR DUE TO POOR JUDGEMENT IN SELECTION OF BRANCH TAKE-OFF FITTINGS.

# A GENERALIZED COMPUTER PROGRAM FOR AIR DUCT ANALYSIS

A COMPUTER PROGRAM IS DESCRIBED THAT WAS DEVELOPED FOR THE PURPOSE OF ANALYZING ANY GENERAL AIR DUCT SYSTEM. THE PROGRAM HAS THE CAPABILITY OF ANALYZING A DUAL OR SINGLE AIR DUCT SYSTEM COMPOSED OF DUCT WITH ROUND OR RECTANGULAR CROSS-SECTION. IT WILL ANALYZE A DUAL DUCT SYSTEM FOR A NUMBER OF DIFFERENT DISTRIBUTIONS OF AIR BETWEEN THE COLD AND WARM SIDES. IT HAS A FEATURE THAT ALLOWS THE HEADER DUCT TO BE ANALYZED FOR THE PROBABILITY THAT ALL BRANCH DUCTS WILL NOT DEMAND MAXIMUM FLOW. THE CAPABILITIES OF THE PROGRAM, ITS USE, METHOD OF ANALYSIS AND FORM OF OUTPUT ARE DISCUSSED.

## SUMMARY

THE CONFERENCE WAS VERY ILLUSTRATIVE, HOWEVER, THERE WERE SOME ASPECTS THAT HAVE NOT BEEN COVERED IN THIS REPORT, OR IF SO, VERY BRIEFLY. THE REASONS FOR THE ABOVE CAN BE DIVIDED INTO THE FOLLOWING CATEGORIES:

1) THE SUBJECT DID NOT HAVE DIRECT RELATION WITH COMPUTERS - "APPLICATION OF RESISTANCE CAPACITANCE ANALOGS TO THERMAL DESIGN PROBLEMS"
2) THE SUBJECT DEVELOPMENT IS MORE THE RESPONSIBILITY OF EQUIPMENT MANUFACTURERS - "SELECTION OF FAN BY COMPUTER TECHNIQUES"
3) THE SUBJECT DOES NOT CONSUME THAT MUCH TIME TO WARRANT THE APPLICATION OF COMPUTERS IN MOST INSTANCES, BECAUSE VARIOUS PARAMETERS HAVE ALREADY BEEN ESTABLISHED, PHYSICAL DIMENSIONS AND ALSO A LIMITATION AS TO THE MAXIMUM DEPTH, THEREFORE ONLY THE DEPTH HAS TO BE DETERMINED - "SELECTION OF COOLING COIL BY COMPUTER"
4) THERE ARE SO MANY POSSIBLE INTERPRETATIONS AND CONFLICTS THAT SIZES ARE MANY TIMES LIMITED BY THESE. - "COMPUTER DESIGN OF HIGH VELOCITY DUCT SYSTEMS" AND "USING THE COMPUTER IN DUCT DESIGN"

ONE OF OUR GOALS IN WRITING THIS REPORT IS TO COVER THE PRESENT AND FUTURE USES OF COMPUTING TECHNIQUES IN THE AIR CONDITIONING FIELD, IN THESE CONFERENCES. HOWEVER, OUR MAIN GOAL IS THAT WE HOPE TO IMPRESS THE READER WITH A SENSE OF READINESS, BECAUSE, AS BEFORE STATED BY ONE OF THE SPEAKERS, "THE DAY IS NOT FAR TO COME, WHERE COMPUTERS, OR MEANS TO COMMUNICATE WITH A COMPUTER WILL, BE JUST LIKE ANOTHER UTILITY".

WHILE THE RECOMMENDATION OF THE REPORT IS FOR THE MOST PART NEGATIVE INSOFAR AS THE USE OF COMPUTERS FOR DESIGN BY THE SMALL OFFICE IS CONCERNED AT THIS TIME, THERE SHOULD BE AN AWARENESS OF THEIR USEFULNESS IN CONTROLLING THE ENVIRONMENTAL EQUIPMENT WE SPECIFY FOR OUR CLIENTS TO ENSURE THE MOST EFFICIENT OPERATION.